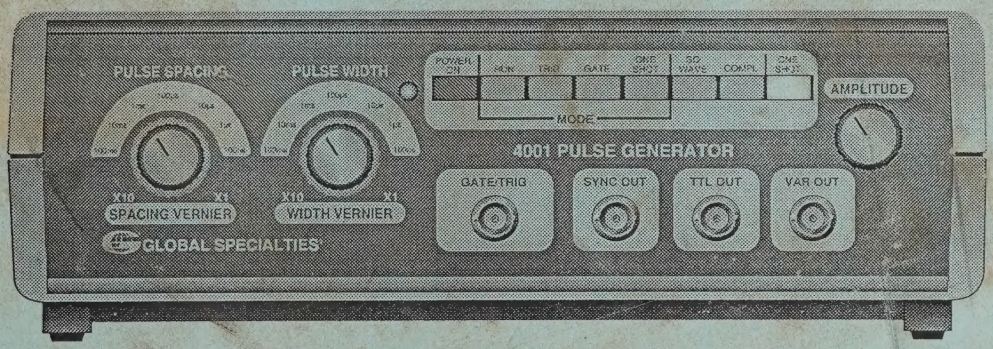
THE 4001 ULTRAVARIABLE PULSE GENERATOR

Operation Manual



GLOBAL SPECIALTIES®
70 Fulton Terrace, P.O. Box 1942
New Haven, Connecticut 06512
(203) 466-6103 • FAX (203) 468-0060

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UNIVERSITY OF CALIFORNIA

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4001 SPECIFICATIONS

Frequency Range:	0.5 Hz to 5 MHz
Pulse Width and Spacing Controls:	100nsec.-1sec in 7 overlapping ranges. Independent variable width and spacing controls. Two concentric, single-turn verniers provide continuous adjustment between ranges.
Duty Cycle:	10^7-to-1 range, cont. adjustable
Accuracy: (Pulse Width and Spacing)	±5% typical, ±15% @ max vernier setting.
(Amplitude)	±5% of control setting.
Jitter:	Less than 0.1%+50psec.
Operating Modes (pushbutton selectable)	
Run:	0.5 Hz to 5 MHz, frequency settable through pulse width/spacing controls.
Trig:	DC to approximately 10 MHz from external source.
Gate:	Generator starts synchronously with leading edge of gate signal-"One Shot" pushbutton can manually activate gate in this mode.
One Shot:	Enables manual"One Shot" pushbutton.
Square Wave:	Square wave may be obtained at the outputs by depressing "Square Wave" pushbutton.

Complement:	Outputs may be inverted by depressing the "COMPL" pushbutton, without losing sync time reference. NOTE: pulse spacing controls not active during "Trigger" and "One-Shot" modes.
Trig/Gate Input:	TTL compatible input, DC coupled logic input: pulses>2.4V peak>40nsec wide. Sine wave input:>1.7V RMS<10MHz. Input impedance: 400Ω max. input: ±10V.
Output: Var Out	Amplitude, 0.5-10V, adjustable via single turn vernier; rise/fall time 30nsec; impedance, 50Ω
TTL Out:	Fan out,40 TTL loads; sink, 64mA at 0.8V maximum; rise/fall time: less than 20nsec.
Sync Out:	Amplitude 2.4V minimum; fan out, 10 TTL loads; sink, 16mA at 0.8V maximum; rise/fall time, less than 20nsec; sync pulse lead time, greater than 20nsec.
Power:	105-125VAC, 50/60 Hz 220-240VAC, 50/60 Hz (Optional)
Operating Temperature:	0° C to 50° C (calibrated at 25° C ±55° C). 32° F to 122° F (calibrated at 77° F±9° F).
Size (WxHxD):	10" x 3" x 7" (254 x 76 x 178mm).
Weight:	2.2lbs. (1 kg)

INTRODUCTION

The Global Specialties 4001 Ultravariable Pulse Generator is a reliable low cost Pulse Generator. Its uncomplicated rugged design and high quality components ensure long and dependable service. The 4001 offers these features:

Separate TTL Output
A Variable Output from 0.5V to 10V
5Ω Output Impedance
Pulse Width Range from 100nsec to 1sec

DESCRIPTION:

The Model 4001, primarily designed as a pulse or clock source, is compatible with IC and discrete component circuits. It also finds application as a system stepper (One-Shot Mode), gated oscillator (Gate Mode), or pulse stretcher (Trigger Mode). With a minimum of adjustments, the 4001 can also serve as a missing pulse detector or a frequency discriminator. The output can be complemented or converted to a square wave with a push of the button.

The Model 4001 offers two Simultaneous Independent Outputs (TTL and Variable) with rise and fall times less than 30nsec; 20nsec TTL compatible leading-edge Sync pulse output. There are independent pulse width and pulse spacing controls (both selectable form 100nsec to 1sec) eliminating incompatible frequency and pulse width settings. Also on the panel are four pushbutton selectable operating mode switches marked (Run, Trigger, Gate and One-Shot).

LOCATION AND DESCRIPTION OF OPERATING CONTROLS

Refer to Figure 1 for the location of all operating controls. These numbers will be referred to throughout the text.

NOTE
All pushbutton switches are push-to-activate switches.

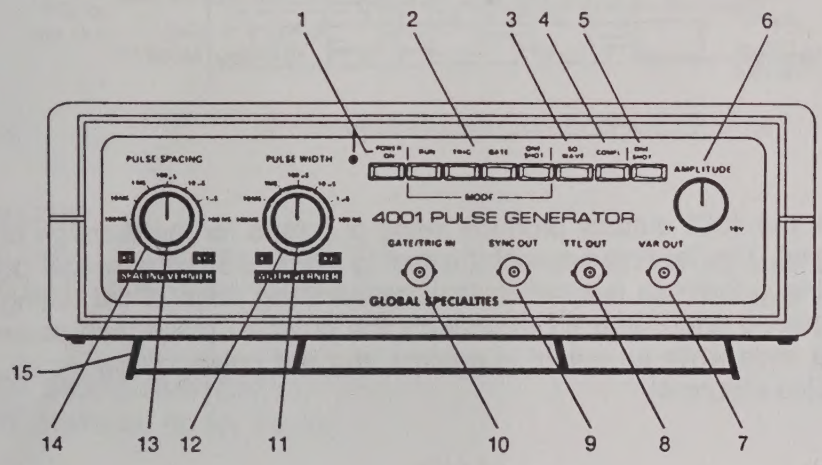


FIGURE 1. Location of Operating Controls

POWER Switch and LED Indicator: (1)
MODE Switch (2)

NOTE
The four Mode Switches(2) are mechanically interlocked allowing only one switch to be activated at a time. They are designated RUN, TRIG and ONE-SHOT.

RUN:
In the Run mode, the 4001 is self-oscillating. All external inputs are disconnected, and all timing controls are functional. (See Figure 2)

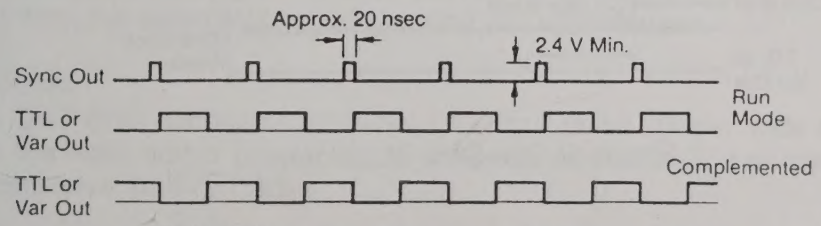


FIGURE 2. Run Mode and Complemented

TRIG:
In the Trig mode, the 4001 outputs produce a synchronous positive going output pulse for each positive input trigger. The output pulse width is adjusted by the Pulse Width and Width Vernier controls. The output pulse is initiated by the positive-edge of the input trigger. When the mode switch is in the Trigger mode, the Pulse Spacing and Spacing Vernier are inactive. (See Figure 3)

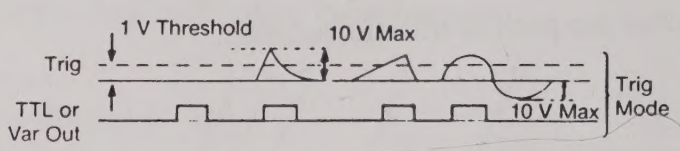


FIGURE 3. Trig Mode Waveforms.

GATE:
In the Gate mode, the 4001 outputs produce trains of pulses for the duration of the applied gating signal. The leading edge of the gating signal starts the output pulse train. The first pulse in the train is synchronized with leading edge of the gating signal. Both the Pulse Spacing and Pulse Width controls the program pulse train parameters. If the gating pulse ends while an output is present, the last pulse will be complemented. (See Figure 4).

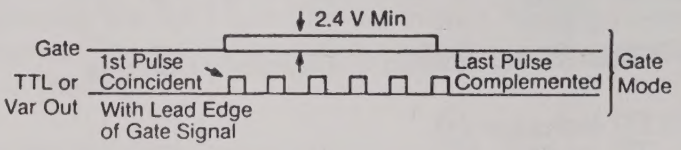


FIGURE 4. Gate Mode Waveforms.

ONE-SHOT:
In the One-Shot mode, the mode switch is latched and the One-Shot pushbutton (5),when pressed, initiates an output pulse. Pulse parameters are set by the Pulse Width (11) and Width Vernier controls. Pulse Spacing and Spacing Vernier controls are not active. (See Figure 5)

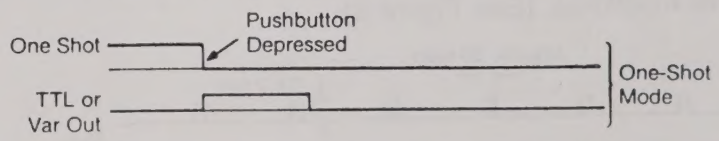


Figure 5. One-Shot Waveforms.

SQUARE WAVE: (3)
When this button is depressed the output is converted to a square wave. The output now changes state with every positive edge of the original "Programmed" waveform. This divides the frequency of the signal by two. All inputs and controls are still functional. (See Figure 6)

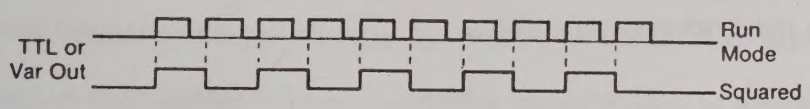


FIGURE 6. Run Mode and Squared Waveforms

COMPLEMENT: (4)
When this button is depressed the TTL and Variable outputs are automatically complemented. All inputs and controls are still functional. (Ref. Figure 2)

ONE-SHOT MODE SWITCH: (5)
See MODE switches (2) for details.

AMPLITUDE CONTROL: (6)
The AMPLITUDE control adjusts the amplitude of the voltage at the VAR OUT BNC connector from 0.5 Volts to 10 Volts.

VAR OUT: (7)
The VAR OUT BNC connector provides a convenient means for interconnecting the generator output to its destination. The VAR OUT signal has a rise and fall time of 30nsec and output impedance of 50 ohms.

TTL OUT: (8)
The TTL Output BNC connector is fed by four TTL gates in parallel, providing a TTL fanout of 40. Rise and fall times are less than 20nsec. Both TTL and VAR OUT pulses are derived from the same internal source and are synchronous.

SYNC OUT: (9)
The SYNC OUT BNC connector produces an output pulse 20nsec wide and 20nsec in advance of the main output pulses. The Sync pulse amplitude is a minimum of 2.4 Volts and can drive 10 TTL loads.

GATE\TRIG INPUT: (10)
The GATE\TRIG input terminals are DC coupled to the 4001 internal circuitry. The input signal can be a sine wave greater than 1.7V RMS or a positive pulse greater than 2.4V.

NOTE Amplitude must not exceed ±10V.

WIDTH VERNIER: (11)
The WIDTH VERNIER is used for continuous adjustment of pulse width between the limits of the range set on the PULSE WIDTH SWITCH. A slight overlap at both ends of the Vernier range insures continuous adjustment over the entire seven decades of pulse width adjustment.

PULSE WIDTH SWITCH: (12)
The PULSE WIDTH switch is used to select output pulse widths from 100nsec to 1sec in seven ranges. When used in conjunction with the Width Vernier, continuous adjustment over the instrument range is achieved.

SPACING VERNIER: (13)
The SPACE VERNIER is used for continuous adjustment of pulse spacing between the limits of the range set on the pulse spacing switch. A slight overlap at both ends of the vernier range insures continuous adjustment over the entire seven decades of pulse spacing adjustment.

PULSE SPACING SWITCH: (14)
The PULSE WIDTH switch is used to select output pulse spacing from 100nsec to 1sec in seven ranges. When used in conjunction with the SPACING VERNIER, continuous adjustment over the entire instrument range is achieved.

FLIP-UP LEG ™ : (15)
Easily raised or folded. Elevates the front of the generator 1 1/2 inches.

FUSE HOLDER: (REAR PANEL)
The fuse post is mounted to the rear panel. (See Figure 14).

CHECKING OUT THE 4001

To check out the Model 4001 Pulse Generator the following equipment is required. (See Figure 7).

1. A dual-trace oscilloscope, 100MHz bandwidth minimum. (Hewlett Packard Model 1740 or equivalent)

2. A TTL-level frequency source. (Global Specialties Model 2001 or equivalent)

3. Three BNC-to BNC cables (Global Specialties Model PSA-2 or equivalent)

4. A 50 ohm terminator.

Procedure
Plug the 4001 into a power source of the proper voltage and frequency. (105 to 115VAC, 60Hz or 210 to 230VAC, 50 to 60Hz) Press in the POWER ON switch. The LED adjacent to the switch will illuminate.

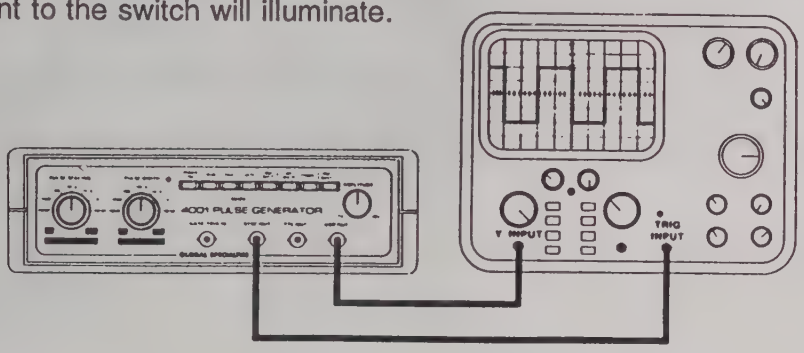


FIGURE 7. Checkout Configuration.

Step A:
Set the controls on the 4001 as follows:

CONTROL	POSITION
Power SW	ON
Pulse Width SW	100ns
Pulse Spacing SW	100ns
Width Vernier	X1 (fully clockwise)
Spacing Vernier	X1 (fully clockwise)
Run Mode SW	IN
Square Wave SW	Normal Out Position
Compl SW	Normal Out Position
Amplitude Cntrl	10V (fully clockwise)

Step B:
Connect one BNC-to-BNC cable from the 4001 TTL OUT BNC to the oscilloscope channel "A" input.

Connect the second BNC-to-BNC cable from the 4001 SYNC OUT BNC to the oscilloscope channel "B" input.

Step C:
Set the oscilloscope in the ALT mode to trigger on the rising edges of the "B" input, with a sweep speed of 50ns per division or faster.

Observe that the.....

SYNC pulse rise and fall times are less than 20ns.
Pulse width is approximately 20ns.
Amplitude is 2.4V minimum.
Rising edge of the SYNC pulse leads the rising edge of the TTL pulse by approximately 20ns.

Step D:
Press in the COMP switch on the 4001.

Observe that the.....

Rising edge of the SYNC pulse leads the falling edge of the TTL pulse by approximately 20ns. (See Figure 8).

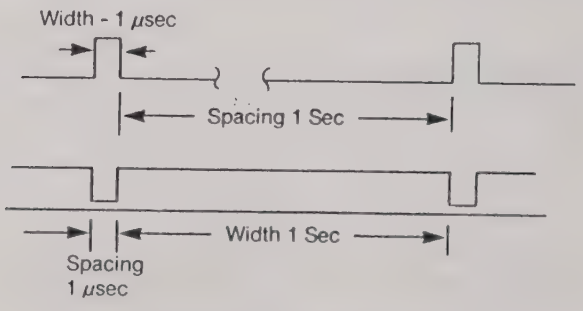


FIGURE 8. Waveforms.

Step E:
Return the COMP switch to it's normal position.

Observe that the.....

Rise and fall times of the TTL Output are less than 20ns.

NOTE:
Some overshoot or ringing may have been observed on the TTL signal. This is a result of the undampened transmission line effects of the BNC cable and is not inherent to the waveform. The same form of distortion may also be in evidence during the following steps where the VAR OUT signal is used. These reflections will cease to exist once proper impedance matching is obtained.

Step F:
Disconnect the BNC cable from the TTL OUT and connect to VAR OUT.
Rotate the AMPLITUDE pot from its fully clockwise position to its fully counterclockwise position.

Observe that the.....

Waveform amplitude decreases from its initial 10V value to a 0.5V level.

Step G:
Set output amplitude to 5V.
Connect the 50Ω terminator at the oscilloscope "A" channel input in-line with the BNC cable.

NOTE
Many oscilloscopes have a 50Ω terminator that may be used in place of the external terminator.

Observe that the....

Output amplitude is now 2.5V and that ringing previously present due to impedance mismatching no longer appears.

NOTE
VAR OUT rise and fall times are less than 30ns.

Observe that the....

Pulse width and pulse spacing are each 100ns ±5%.

Step H:
Rotate the WIDTH VERNIER to its "X10" position. Note that the pulse width is now 1μsec ±15% and that the pulse spacing is unchanged.

Press in the COMP switch and note the waveform inversion.

Press in the SQUARE WAVE switch. Note that the resulting waveform has a pulse width of 1.1μsec and a pulse spacing of 1.1μsec,(the sum of the WIDTH and spacing settings) for a total of 2.2μs.

Return the SQUARE WAVE and COMP switches to their normal (OUT) positions.

STEP I:
Rotate the SPACING VERNIER to its "X10" position. Note that the pulse spacing is now 1usec ±15%.

Change PULSE SPACING and PULSE WIDTH to 1μs.

Observe....
A pulse width and pulse spacing of 10μsec ±15%.

STEP J:
Observe....
A pulse width and pulse spacing of 1μs ±5%.

Change PULSE WIDTH and PULSE SPACING to 10μs.

Observe....
A pulse width and pulse spacing of 10μs ±5%.

STEP K:
Rotate the WIDTH VERNIER and SPACING VERNIER to "X10".

Observe....
A pulse width and pulse spacing of 100μsec ±15%.

Change the PULSE WIDTH and PULSE SPACING to 100μs.

Observe....
A pulse width and pulse spacing of 1msec ±15%.

STEP L:

Observe....

A pulse width and pulse spacing of 100μs ±5%.

Change the PULSE WIDTH and PULSE SPACING to 1ms +\-5%.

STEP M:
Rotate the WIDTH VERNIER and SPACING VERNIER to "X10".

Observe....

A pulse width and pulse spacing of 10msec ±15%.

Change PULSE WIDTH and PULSE SPACING to 10ms.

Observe....

A pulse width and pulse spacing of 100msec ±15%.

STEP N:
Rotate the WIDTH VERNIER and SPACING VERNIER to "X1".

Observe....

A pulse width and pulse spacing of 10ms ±5%.

Change the PULSE WIDTH and PULSE SPACING to 100ms.

Observe....

A pulse width and a pulse spacing of 100ms ±5%.

STEP O:
Rotate the WIDTH VERNIER and SPACING VERNIER to "X10".

Observe....

A pulse width and pulse spacing of 1sec ±15%.

Change the PULSE WIDTH and PULSE SPACING to 1ms.

Press in the ONE-SHOT mode switch.

Momentarily push in the white ONE-SHOT pushbutton.

Observe....

One single 10ms pulse is generated for each actuation of the pushbutton.

STEP P:
Press in the TRIG mode switch.

Connect a TTL-level, 2Hz signal from a TTL-level frequency source to the GATE\TRIG IN connector on the 4001 pulse generator using a BNC cable.

Observe....

A 10ms pulse occurring at the 2Hz rate.

STEP Q:
Press in the GATE Mode switch.

Observe....

Pulse bursts occurring at a 2Hz rate.

STEP R:
Turn off the power and disconnect all cables. This concludes the 4001 pulse generator checkout.

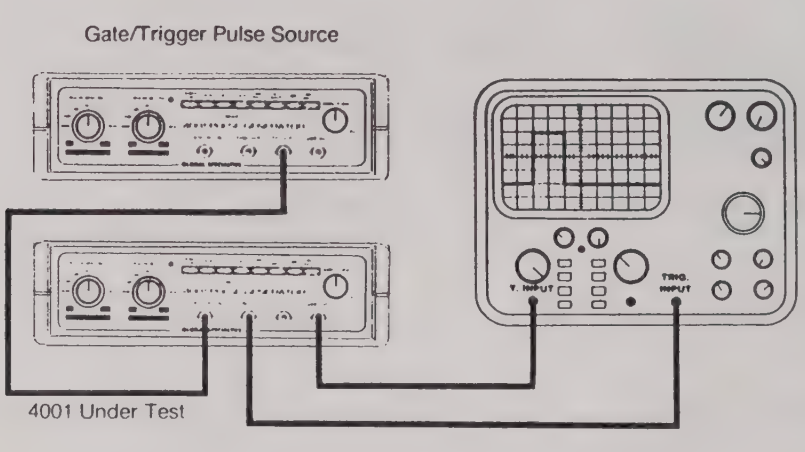


Figure 9. Checking Trigger and Gate Modes.

APPLICATIONS

The 4001 Pulse Generator with its many features and ease of operation make it a welcome addition to any lab.

The following is just a sampling of the varied uses of the 4001.

Missing-Pulse Detector

Program the 4001 pulse width for 10μsec. Set the input trigger pulse repetition period (PRP) to 8μsec. Each time the trigger pulse goes positive, the 4001 is reset and must time out to its full 10μsec.

The outputs of the 4001 remain in the High State. If one of the trigger pulses is not present (missing) the 4001 output will time out to 10μsec and then return to its low state until the next trigger pulse occurs. (See Figure 10).

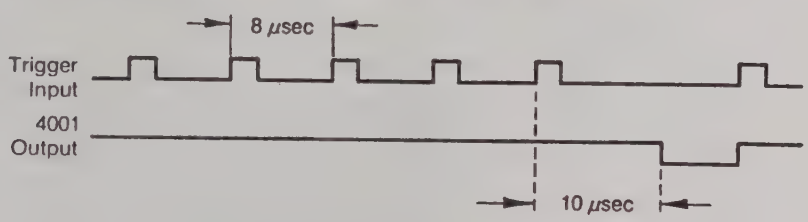


FIGURE 10. Missing Pulse Detector Application.

TRACING DIGITAL LOGIC FLOW

The 4001 and a digital logic probe such as the Global Specialties LP-3 make an excellent troubleshooting system. Just use the 4001 as a signal injector to inject either a pulse train, a single one-shot, or the complement of either. Then trace through the circuits with the LP-3 and quickly find the defective component.

ANALYZING A MICROPROCESSOR PROGRAM

By substituting your 4001 for the microprocessor system clock you can give your microprocessor the capability of stepping through its microprogram either a step at a time (in the One-Shot mode) or at much reduced speed, by using long timing periods in the "RUN" mode.

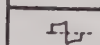
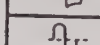
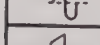
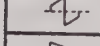
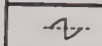
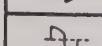
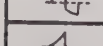
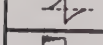
Note, however, that some microprocessors have a minimum clock speed, below which correct operation is not assured. If in doubt, check the data sheet for the microprocessor that you are using.

TESTING RADIO CONTROL RECEIVERS

Proportional radio control is usually implemented by sending a variable mark-space ratio low frequency modulation on a radio frequency signal. Your 4001 may be used to simulate the radio transmitter when testing the low-frequency stages of your receiver. The 4001 is also ideal for simulating the joystick input to the transmitter.

AUDIO TESTING

The 4001 again shows its versatility in testing audio amplifiers. Square waves are used in audio testing to display a wide range of frequencies simultaneously. Square waves consist of a fundamental frequency, and a series of odd harmonics to square off the wave shape.

Waveform	LF Gain	LF Gain	HF Gain	HF Gain	Damping
	OK	OK	OK	OK	OK
	L	OK	H	OK	H
	H	OK	L	OK	H
	OK	H	OK	L	H
	OK	L	OK	H	H
	H	H	L	L	H
	H	L	L	H	H
	L	H	H	L	H
	OK	OK	H	OK	OK
	OK	OK	H	OK	L
	OK	OK	H	OK	LL
	OK	OK	*	OK	L

*Sharp Cutoff or Peaked

L = Low
LL = Very Low
H = High
OK = Suitable Proper

TABLE 1. Typical Square Wave Patterns and an Interpretation of These Shapes.

For an amplifier to reproduce a square wave it must have a flat frequency response from 0.1F to 10F where "F" is the fundamental frequency of the square wave.

The traditional test frequencies are 50Hz for the low frequency test and 10KHz for the high frequency end. (See Table 1)

Connect the 4001 to the amplifier under test as shown in Figure 12 and observe the output on the scope. Table 2 shows the table of power and voltage relationships for 4Ω and 8Ω speakers. It also lists the output voltage level for 10dB below the maximum output of amplifiers with different power ratings. Choose the rating closest to the amplifier under test. Testing at 10dB below maximum output ensures that the amplifier will not be in saturation. This level is approximately 2/3 of the full power output.

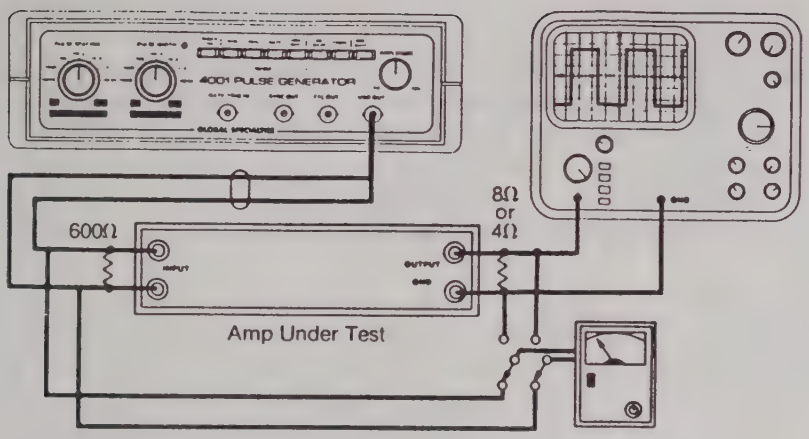


FIGURE 11. Amplifier Frequency Response Test.

Power Ratings (RMS)			Output (RMS)	
8Ω	4Ω	E^2	Full Output	10 dB Below Max Output
1 W	2 W	8 V	2.8 V	2.3 V
5 W	10 W	40 V	6.3 V	5.2 V
10 W	20 W	80 V	8.9 V	7.3 V
20 W	40 W	160 V	12.6 V	10.3 V
50 W	100 W	400 V	20.0 V	16.3 V
100 W	200 W	800 V	28.0 V	23.1 V

TABLE 2. Power/Output Relationships

TESTING TRANSMISSION LINES

If a transmission line is not terminated at the far end by its characteristic impedance, reflections will occur. This phenomenon can be used to find faults on transmission lines. Using your 4001 you can find out if the cable under test is open, or short circuited, and with some simple calculations, you can find the length of the cable.

Equipment
1-4001 Pulse Generator
1-50Ω coaxial cable to be tested(≅10m long)
1-oscilloscope
1-passive probe 10:1
1-50Ω termination
1-adaptor banana female-BNC male
1-BNC T connector

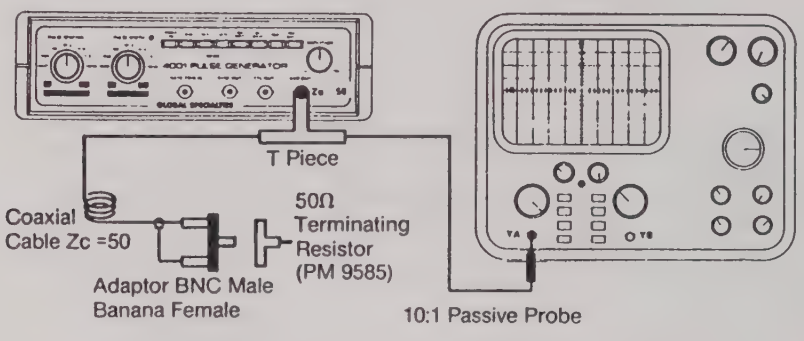


FIGURE 12. Transmission Line Test

Set up the equipment as shown in Figure 12.

Set the 4001 to:
Amplitude-6.5V
Pulse width time-5μsec
Pulse space time-5μsec
Square Wave-engaged
(use VAR. output connector)

Set the scope to:
Vertical Display-1V/cm
Input Coupling-DC
Trig Source-Int
Trig Mode-Audio
Trig Level-Adjusted
Sweep Time-2μsec/cm

With the far end open, the scope should display a signal as shown in Figure 13. The final amplitude is reached in two steps. At the moment the 4001 meets the 50Ω of the cable itself, the output is at nominal value (midscale dots B on Figure 13) and a reflection takes place at the open end. When this reflection feeds back to the pulse generator output, it tells the 4001 that the far end is open, and the open circuit voltage of the 4001 appears.

Now change the Time/Div of the scope to 0.1μsec and observe the signal in Figure 13. The time between points "A" and "B" is the time it takes for the missing signal to reach the open end and return. For example, assume that (as in Figure 13A) the reflection takes 120nsec. It is known that the velocity of a signal in a coaxial cable is about 0.7C (C=3x10^8 m/sec). If the cable has the length "L" it will take 2L/0.7C before the signal returns as a reflection. Using the time observed on the scope the cable length is calculated as shown:

$$T=\frac{2L}{0.7C}$$ where "T" is TIME for Reflection

Solving for "L" we get:

$$L=\frac{0.7CT}{2}$$

$$L=\frac{(0.7)\,x(3x10^{8}/\,msec)\,x(120\,x10^{8}\,\mathrm{sec})}{2}$$

Remember that the accuracy of this result is determined by the Time-Base accuracy. Short circuiting the end of the cable results in the waveform shown in Figure 13B and 13C. After 120nsec the 4001 "knows" that its output is short circuited and the voltage drops to zero. The cable load influences this ideal behavior and zero means "almost"zero. The cable load influences this ideal behavior and zero means "almost" zero, which can be noticed from the offset level with respect to the start.
Terminating the far end with 50Ω results in the waveform(shown in Figure 13D). Matching the far end of the cable with a resistor equal to the characteristic impedance completely eliminates reflections from the far end, resulting in a perfect square wave at the generator end of the cable.

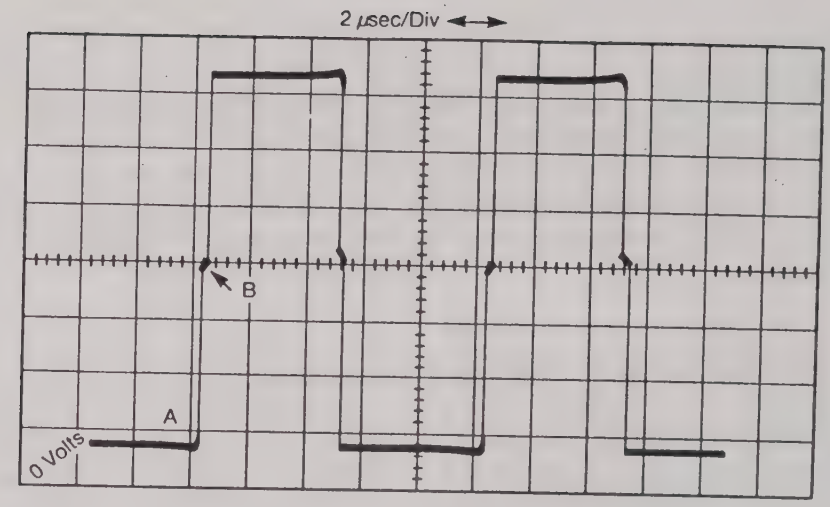


FIGURE 13. Scope Waveform Patterns-Transmission Line Testing.

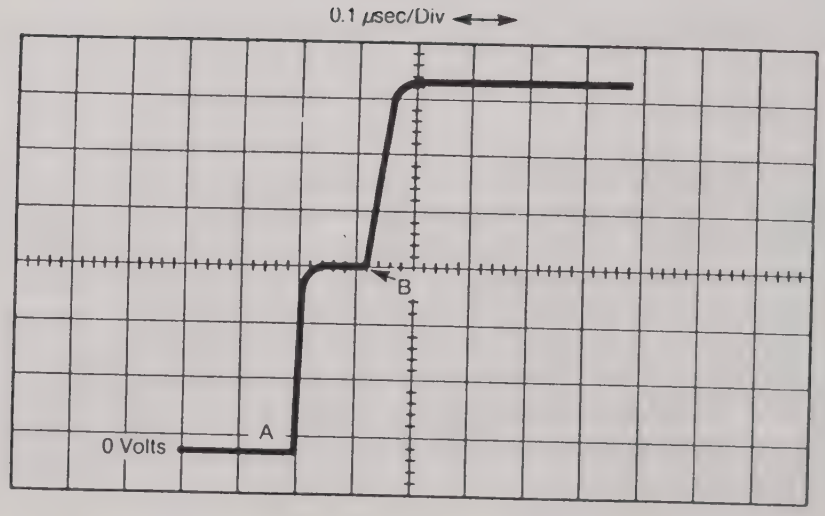


FIGURE 13A. Scope Waveform Patterns-Transmission Line Testing.

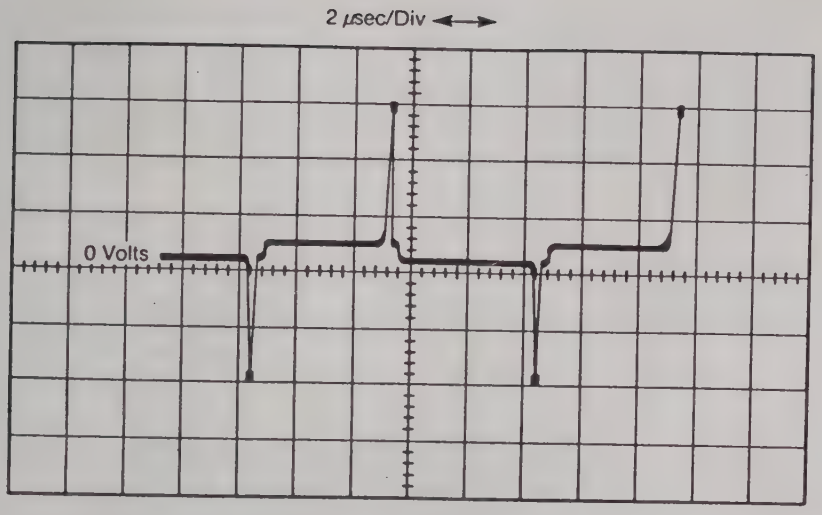


FIGURE 13B. Scope Waveform Patterns-Transmission Line Testing.

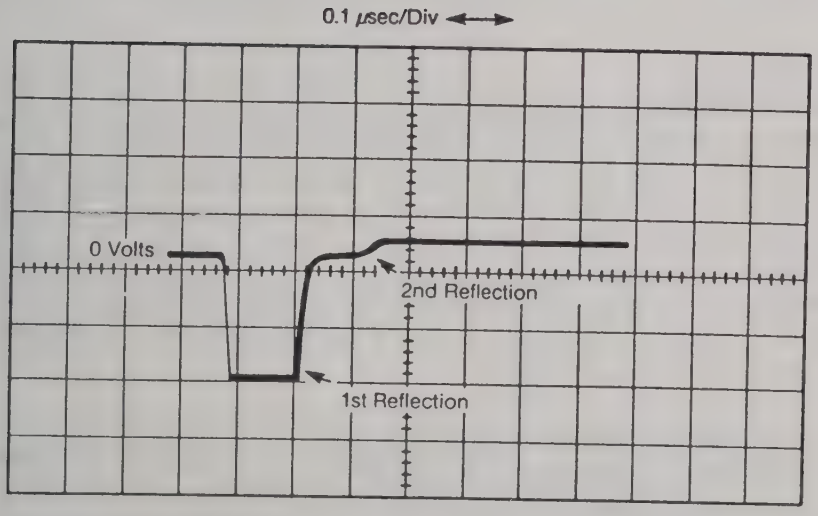


FIGURE 13C. Scope Waveform Patterns-Transmission Line Testing.

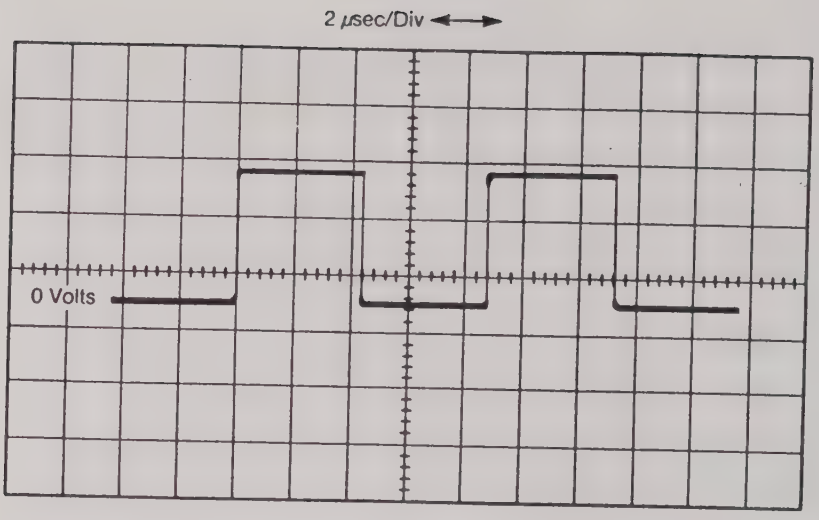


FIGURE 13D. Scope Waveform Patterns-Transmission Line Testing.

CIRCUIT DESCRIPTION

Figure 15 shows the schematic diagram of the 4001 Pulse Generator. The heart of the pulse generator is the integrated circuit A-1 dual monostable multi-vibrator #74123. The two monostable multi-vibrators are cross-coupled from the "Q" output of the first to the "A" input of the second and vice-versa.

Anti-Latch Circuit Operation
The cross-coupled monostabled multi-vibrator circuits as long as their "B" inputs are high. However, since the coupling between the two circuits is purely DC it is possible for he oscillator to latch-up. The problem is overcome by a special triggering circuit that is gated on if a1 fails to oscillate. Transistors Q3 and Q4 form a hook oscillator. R30 and R32 bias the base of Q3 to 1/2Vcc while the emitter of Q3 is controlled by R28 and R29. These resistors are connected to the Q output of the A1-1 and A1-B. As long as A1 oscillates, one of the Q outputs will be high. The average voltage at the emitter of Q3 will be half the Q high voltage. This holds the emitter of Q3 more negative than its base, and Q3 is cut off.

If the oscillator stops, both Qs go high. Q3 emitter voltage rises above its base voltage and starts to conduct. Q3 and Q4 turn on and latch, discharging C18. As Q3 and Q4 recover from the latch condition, the "B" input of A1-A goes high, forcing Q of A1-A low, turning off the hook circuit and restarting the oscillator.

Timing Circuit Operation
The timing of A1-A is controlled by the selection of capacitors C1 through C7 and R1 through R10.
The timing resistor R9 or R10 and the trim pots R1 and R7 set the range for R8, the Spacing Vernier, for each of the pulse spacing switch positions. A1-B timing system is the same as A1-A.

Mode Switch Operation

Run Position
In the run mode, S3 removes the 5 volts from the input to A5-B causing the output to go high, enabling the oscillator.

Trig. Position:
In the trig. position, S4 applies 5 volts to R31, Q4 saturates and shorts the "B" input of the A1-A to ground, disabling A1-A. When a positive trigger pulse appears at J4, Q5 emitter goes high and A5-A low, A5-B goes high, triggering A1-B on.

Gate Position:
In the gate position, S5 ties both the base of Q3 and the "B" input of A1-A to the 5 volt line through a 1K resistor (R33) turning off Q3 and insuring that A1-A is in the oscillator mode.
To gate the oscillator on, a positive voltage is applied to J4, which via emitter-followed Q5 causes A5-A to go low, A5-B to go high, and the oscillator to start. The oscillator will continue to run while the gate signal is present. When the gate is removed, the oscillator completes its final cycle.

One-Shot Position:
The pushbutton fires a J-K Flip Flop (A2-A) whose output turns off Q5 through CR2 and R44. This manually simulates the input of a trigger pulse.

Output Circuit Operation

TTL Out:
The TTL output is derived from four two-input NAND gates. A 4.7? resistor limits the output drive to 40 TTL loads.

Var Out:
Q2 is the final driver for the VAR output. The collector of Q2 is tied to Vcc while the base is tied to the collector of Q1 through a 47Ω resistor. The collector of Q1 is tied high through a 330Ω resistor and is also shunted to ground by a 2.5K a amplitude pot. Q1 and CR1 also provide active pulldown for the output when it is low.
The output is fed via a 47Ω resistor, providing the correct impedance and overload protection.

Sync. Out:
The inputs of A4-D are connected to a timing chain consisting of 3 TTL gates (A3-A,A3-B,A4-A) and R39,C19. The output of A3-D is normally high. When it goes low, there will be a brief interval before the signal reaches the output of A4-A in which neither input of A2-D will be high, and so a sync will be generated. Depending on the position of the complement switch, the first transition of the output will either be simultaneous with the falling edge of the sync pulse or 15nsec after it.

Power Supply:
A plug-in type power supply supplies raw DC, plus (+) and (-) through the power switch directly to the regulators.

RECALIBRATION PROCEDURES

Fuse Replacement
The 4001 is protected by a type 3AG slo blo 1/4 amp (1/8 amp for 230V) 250V power fuse. The fuse is accessible at the rear panel of the unit. If replacement of the fuse should become necessary, follow this procedure:

1. Disconnect the AC power cord.
2. Use a screwdriver to remove the fuse cap holding the fuse and remove the fuse.
3. Insert fuse with correct rating.

NOTE: New fuses seldom fail without malfunction of the instrument. Repeated replacement of the fuse without correcting the problem may cause further damage.

Case Disassembly and Assembly
To open the case, turn the unit upside down with the rubber feet facing up (see Figure 14). Remove the four pads from the plastic feet. Remove the screws from the center recess of each of the four feet.

Note
The flip-up leg will automatically come free with the front feet.

Carefully separate the two halves of the case and recalibrate the unit. To close the case, lower the case bottom and guide the front and rear panels into their slots. Position the rubber feet as illustrated and screw the two halves of the case together. Do not overtighten screws. Install the four rubber pads.

Recalibration Procedure

Before being shipped, your 4001 Pulse Generator went through a very thorough series of tests and calibration. If recalibration becomes necessary, follow the instructions outlined below carefully. Do not attempt to recalibrate this unit unless you have enough experience in the use of an oscilloscope. See warranty (back cover) for limits of liability.

During this recalibration procedure, refer to Figure 1, Control Locations:

1. Disconnect all cables from the 4001. Remove power cord from wall plug.
2. Remove the top case half as outlined in the Case Disassembly procedure. (See Figure 14)

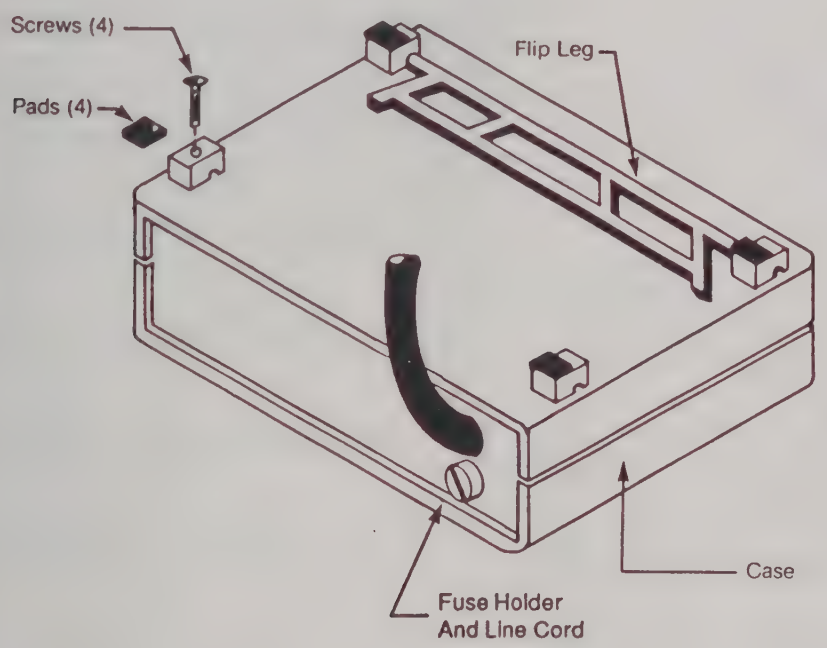


FIGURE 14. Case Disassembly and Assembly

3. Reconnect power and connect the oscilloscope to the TTL OUT BNC on the 4001.

4. Set up 4001 front panel as follows:

CONTROL	POSITION
Power (1)	ON
Mode (2)	RUN
Pulse Width Sw (12)	100ns
Pulse Spacing SW (14)	100ns
Space Vernier (13)	X1
Width Vernier (11)	X1
Square Wave (3)	OUT
Complement (4)	OUT

5. Adjust R17 for a pulse width of 100ns ±5%.
6. Adjust R7 for a pulse spacing of 100ns ±5%.
7. Switch PULSE WIDTH and PULSE SPACING controls to their 1μs positions.
8. Adjust R16 for a pulse width of 1μs ±5%.
9. Adjust R6 for a pulse spacing of 1μs ±5%.
10. Switch PULSE WIDTH and PULSE SPACING controls to their 10μs positions.
11. Adjust R15 for a pulse width of 10μs 5%.
12. Adjust R5 for a pulse spacing of 10μs 5%.
13. Switch PULSE WIDTH and PULSE SPACING controls to their 100μs positions.
14. Adjust R14 for a pulse width of 100μs ±5%.
15. Adjust R4 for a pulse spacing of 100μs ±5%.
16. Switch PULSE WIDTH and PULSE SPACING controls to their 1ms positions.
17. Adjust R13 for a pulse width of 1ms ±5%.
18. Adjust R3 for a pulse spacing of 1ms ±5%.
19. Switch PULSE WIDTH and PULSE SPACING controls to their 10ms positions.
20. Adjust R12 for a pulse width of 10ms ±5%.
21. Adjust R2 for a pulse spacing of 10ms ±5%.
22. Switch PULSE WIDTH and PULSE SPACING controls to their 100ms positions
23. Adjust R11 for a pulse width of 100ms ±5%.
24. Adjust R1 for a pulse spacing of 100ms ±5%.
25. Turn off power, disconnect all cables from the 4001, and reassemble the case as outlined in the Case Reassembly procedure.

This completes recalibration of the 4001.

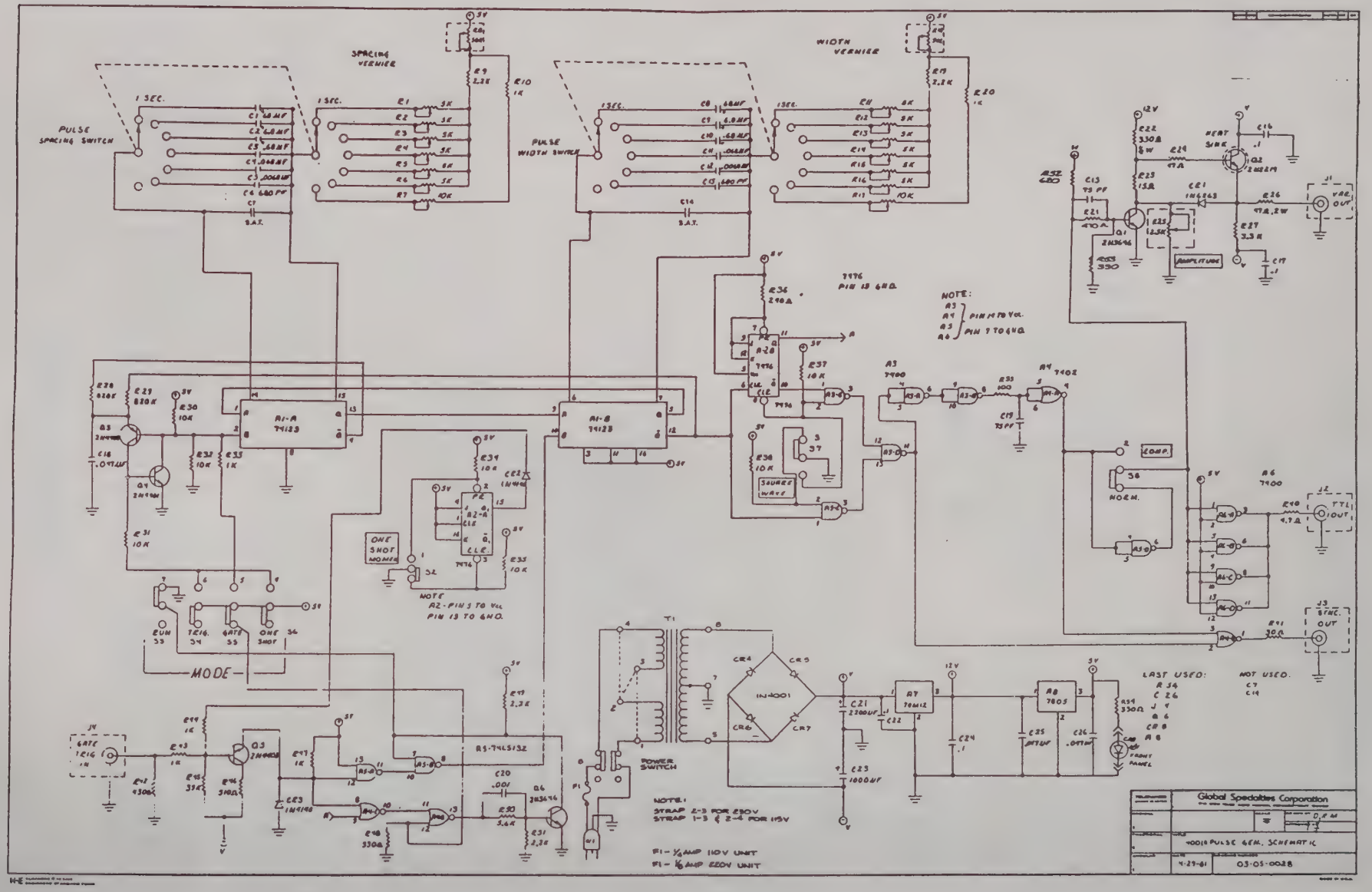


FIGURE 15. Circuit Schematic.

WARRANTY

Global Specialties® warrants this device to be free from defective material or workmanship for a period of one full year from the date of original purchase.

Global Specialties® under this warranty is limited to repairing the defective device when returned to the factory, shipping charges prepaid, within one year from date of original purchase.

Units returned to Global Specialties® that have been subject to abuse, misuse, damage or accident, or have been connected, installed or adjusted contrary to the instructions furnished by Global Specialties®, or that have been repaired by unauthorized persons will not be covered by this warranty.

Global Specialties® reserves the right to discontinue models, change specifications, price or design of this device at any time without notice and without incurring any obligation whatsoever.

The purchaser agrees to assume all liabilities for any damages and/or bodily injury which may result from the use or misuse of this device by the purchaser, his employees, or agents.

This warranty is in lieu of all representations or warranties expressed or implied and no agent or representative of Global Specialties® is authorized to assume any other obligation in connection with the sale and purchase of this device.

FACTORY SERVICE AND REPAIR INFORMATION

Global Specialties® will service and repair this instrument free of charge for a period of one full year, subject to the warranty conditions above.

To obtain a return merchandise authorization (RMA) required for all returns, phone our Customer Service Department for an RMA and all shipping instructions:
Tel. 1-800-572-1028 or write:

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All Global Specialties® breadboarding sockets are guaranteed for life. If a socket ever fails to meet your requirements, return it and we will replace it,
NO QUESTIONS ASKED.

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